MORPHOLOGY AND DISTRIBUTION OF *BASSIA BIRCHII* (F. MUELL.) F. MUELL.

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(Plate XVII)

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Synopsis

Bassia birchii, an unpalatable native shrub, is widespread in semi-arid eastern Australia. Its early history and errors in previous descriptions are discussed. A new description of the species is presented and a spineless form of the species is also noted ; some other variations in morphology are attributed to insect attack. Apart from these variations no consistent differences were found in specimens grown from seeds collected from a wide area. Specimens of the typical form from two widely separated areas in New South Wales and the spineless form all had the somatic chromosome number 2n = 18 and there was no evidence of polysomaty. The range of the plant in eastern Australia is described and the occurrence of serious infestations in New South Wales is surveyed. Distribution is discussed in relation to seasonality of rainfall, winter temperatures and soil type.

INTRODUCTION

Bassia birchii (F. Muell.) F. Muell. is a widespread native shrub which is of considerable economic importance to the sheep grazing industry in semi-arid eastern Australia. It is not usually eaten by stock and in some situations it is so prolific as to exclude useful herbs and grasses. In spite of its importance the species has not been adequately described and the history of its spread and present distribution is poorly documented.

The aim of the present paper was to write a new description of the species, to record its present geographic range and to survey areas of serious infestation in New South Wales. Studies of the ecology and weed status of *B. birchii* are to be reported in future publications.

EARLY HISTORY OF THE SPECIES

Mueller (1874, p. 163) first described the species as *Anisacantha birchii* F. Muell. but in 1882 (Mueller, 1882, p. 30) he re-established the genus *Bassia* All. uniting under it nine genera including *Anisacantha* R. Br. Domin (1921) transferred the type species of *Anisacantha* (*A. divaricata* R. Br.) to *Sclerolaena* R. Br. and placed *A. birchii* in the subgenus *Anisacantha* under the genus *Sclerolaena* (*cf.* Ulbrich, 1934). Anderson revised the Australian species of the genus *Bassia* in 1923 and provided a new description of *B. birchii.*

The species was first collected in 1874 at Bowen Downs (22°28′S, 145°00′E) in Queensland. Bowen Downs was a large station of over 3,500 km^2 and at the time was wholly owned by the Scottish Australian Company Limited. On the station, a township of nearly 60 people was a focal point for a very wide area and

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an important stage on the route to the Gulf of Carpentaria (Macmillan, 1963). The next record of the species is from Morven in Queensland in 1890. There are six other records of the plant in Queensland before it was first recorded in New South Wales in 1916 on a property north-west of Wee Waa. It may be more than coincidental that the Scottish Australian Company had " runs " in this area, to which it moved sheep on at least one occasion (1868) from Bowen Downs (Macmillan, 1963). Early specimens of " *B. birchii* " in South Australia which were recorded by Black (1915, 1916) from Glen Ferdinand in 1915 and Minnipa in 1916 appear to have been later determined as another species by Black or to have been lost ; from Black's descriptions the former appears likely, and it seems probable that the specimens were *B. cornishiana* F. Muell. A report of *B. birchii* by Tate (1896) in the record of the Horn scientific expedition to central Australia is also suspect. Tate observed the plant at Illipa at the base of the Belt Range, but there is no herbarium record of *B. birchii* from that locality.

Anderson (1923) cites specimens in the New South Wales National Herbarium, representing six localities in New South Wales : Wee Waa (1916) ; Walgett (1918) ; Narromine (1920) ; Parkes (1921) ; Gunnedah (1922) and Wingham (?), (dates from herbarium specimen sheets, N.S.W. National Herbarium). The discovery of the plant at Wingham on the north coast of New South Wales seems improbable in view of later records. Inspection of all *B. birchii* material at N.S.W. National Herbarium revealed that all the specimens collected prior to 1923 had been noted by Anderson, with one exception. There is one (NSW 79069) from Wingen, a town on the New England Highway between Murrurundi and Scone, dated 1921. There is no specimen from Wingham. It appears likely that the two place names were confused in the preparation and printing of Anderson's paper.

Whether the plant is native to New South Wales and Queensland or to Queensland alone is uncertain. The first record of the plant is nearly 160 km north of any area where it is now common. Although there are earlier records of related species in New South Wales, the early records of *B. birchii* are not sufficiently comprehensive to establish its origin with confidence. Anderson (1923) did not discuss the origin of the plant. White (1925) was of the opinion that it was native to both States and Blake (1935) believed that its exact geographic origin could not be determined, but neither author discussed relevant evidence.

There is some evidence to suggest that *B. birchii* was a problem weed in Queensland before it became one in New South Wales. A specimen of the species from Wingen, New South Wales (NSW 79069), sent from the Scone Shire Clerk to the Government Botanist in 1921, contains the following note :

> " Inspector Higgins (Inspector of Noxious Plants) says the plant was known twenty years ago as ' Galvanised Roly Poly ' and is a bad one on Goodooga, St. George and Castlereagh country and takes possession of any rich lands if allowed to grow ".

Furthermore, a letter held in the Queensland Herbarium (BRI) dated 11 January 1918, from the Government Botanist to the Shire Clerk at Miles, Queensland, indicates that it was very common on the " [Darling] Downs and western country ".

Yet there is a distinct possibility that the plant had been present in New South Wales perhaps in small quantities prior to 1916 but had been confused with other *Bassia* species. Anderson (1923) in his revision of the genus stated that " this is probably the most unsatisfactorily defined species of the genus ". He noted also that the type specimen " came very close to what I had regarded as a very robust form of *B. quinquecuspis* var. *villosa* ". He also stated that the species *B. quinquecuspis* " is one of the most variable within the genus ". Anderson also confused *B. cornishiana* with *B. birchii*. He stated that from all the material labelled as *B. birchii* at the Melbourne Herbarium three distinct species were present : (i) *Bassia birchii* (represented by the type specimen only) (ii) *Bassia convexula* and (iii) *B. cornishiana.*

Mueller (1890) had suggested that *B. cornishiana* be made a variety of *B. birchii.* The plate labelled *B. birchii* in his *Iconography of Australian salsolaceous plants* (1891, Pl. 72) depicts both *B. birchii* and *B. cornishiana.* Anderson (1923) recognised the shorter branch in the plate as *B. cornishiana*, probably by the six spines on the fruits (*cf.* five for *B. birchii*). However Anderson considered that figs 7–10 (Mueller, 1891, Pl. 72), which are depicted below the branch of *B. cornishiana*, represented the type of *B. birchii.* It will be shown below that this latter judgement was itself in error and further confused the situation.

Morphology

The morphology of the mature fruiting perianth has been used as a key distinguishing character in the genus (Anderson, 1923 ; Ising, 1964) but it has not been adequately described, nor have the flowers been described.

Flowers in *B. birchii* are solitary and axillary. Floral development is protogynous. The flowers are four merous with the spines alternate with perianth lobes. The single style is short and divides into three white bristle-like stigmata (Pl. XVIIB), or occasionally into two or two with one branched, especially in immature plants. There are four stamens which have white translucent filaments and yellow versatile anthers.

The authors have used the term " mouth " to describe the opening of the perianth cavity and " throat " to describe the constricted area immediately below it (Pl. XVIIC). In young plants and sometimes in unhealthy specimens " juvenile " flowers are produced in which stamens remain in a partially developed form within the fruiting perianth (Pl. XVIIA). In some cases in the youngest flowers the perianth remains closed over the tube and no mouth or throat is developed, the differentiation of the style and ovary is limited and no anthers or spines form. In normal mature plants stigmata emerge several days before the anthers are visible above the hairs surrounding the mouth. The anthers remain immediately above the mouth for approximately 24 hours. The filaments then elongate in a few hours and the anthers burst (Pl. XVIIIB) with at least one anther usually coming into direct contact with a stigma. Pollination is thus autogamous but the plant is not an obligate self pollinator. Successful cross pollination of a number of flowers was made and normal embryos and seedlings were produced. There are no nectaries and no insect visitors to flowers were observed. It is quite common for one anther (sometimes two) to become caught in the throat of the tube. Those anthers usually burst and spread pollen on the style and lower parts of the stigmata.

The shape of the tube of the fruiting perianth is rather irregular and variable. It is broadly tubular to ovoid or turbinate and shortly convex on its summit at the mouth of the tube (cf. *B. cornishiana* in which the summit is flat). The base is obliquely attached and the fruit is difficult to remove from the stem.

Ising (1964) in his key to the genus *Bassia* uses the orientation of spines as a distinguishing character. The orientation of spines on *B. birchii* is described as " ± horizontal ", but in fact they are usually in two distinct planes. The fruiting perianth has five divergent acicular spines, two of which occur close together (Anderson's " bifid " spine), adjacent and obliquely parallel to the stem (Pl. XVIIC). The other three spines radiate divergently, obliquely perpendicular to the stem, arising from an equatorial position on the fruiting perianth (in *B. cornishiana* the spines are all approximately in the same plane). The three spines obliquely perpendicular to the stem in *B. birchii* are usually longer than the other two, although one of the three is often reduced (this may vary on adjacent fruits on the same stem). The developing perianth spines have a large number of hairs which senesce as the spines become woody. The base of the hairs (Pl. XVIID) may harden and form a barb which is usually reflexed. The hardening of the base of the hairs appears to be very variable and may be influenced by environmental conditions at the time at which the hairs senesce. Such barbs would considerably increase the tenacity of the propagules in wool and aid in dispersal.

In his key to the genus, Anderson (1923) uses the position of the seed in the fruiting perianth as a principal distinguishing feature and erroneously states that in *B. birchii* it is " usually obliquely horizontal ". Bisalputra (1961) makes the same mistake. Plate XVIIC shows a mature fruiting perianth with one side cut away to reveal the seed, placed almost parallel to the stem and thus lying vertical to obliquely vertical. This is also true for all the specimens from New South Wales which Anderson cited. Moreover, it is true for the seeds and seed cavities in the type, represented by one fruit at Sydney (NSW 61508) and by the Melbourne specimen (C. W. Birch MEL holotype). The source of Anderson's error is probably twofold. First, he regarded figs 7–10 of Mueller (1891, Pl. 72) as representing *B. birchii*. These figures show a horizontally placed seed but they represent *B. cornishiana*. Figure 7 of Mueller's Plate 72 is a median vertical section through a fruiting perianth of *B. cornishiana* which shows cotyledons of the embryo to the left and the radicle to the right with perisperm (see Hindmarsh (1966)) between. Fig. 10 of the same plate is a longitudinal section of the same seed. A median vertical section of a fruiting perianth of *B. birchii* bisects the embryo symmetrically. Secondly, a number of sections of fruiting perianths on the type specimen have been made by previous workers which are not at right angles to, or parallel to, the stem. It would have been difficult, in these cases, to determine the orientation of the seed or seed cavity, particularly as many fruits are squashed. Mueller's original description (1874) did not refer to the position of the seed. Bailey (1901, pp. 1258–60) noted that the seed was vertical in the genus *Anisacantha*, following Bentham's (1870, p. 198) description in *Flora Australiensis*.

Using Anderson's key, *B. birchii* is readily confused with *B. quinquecuspis*; Anderson noted that *B. birchii* " resembles very closely a robust form of *B. quinquecuspis* var. *villosa* Benth." He also noted that *B. quinquecuspis* was " probably the most common species of *Bassia* in New South Wales " and " one of the most variable within the genus ". Its seed position may be " truly vertical, oblique, or almost horizontal, but the oblique condition is most common ". Although Anderson described the leaves of *B. quinquecuspis* as linear-lanceolate (cf. obovate to broadly lanceolate for *B. birchii*), the species includes the variety *semiglabra* (which was not described until 1964 by Ising) which has obovate leaves. *B. birchii* differs from *B. quinquecuspis* var. *semiglabra* most conspicuously in that its leaves are tomentose on both surfaces, whereas the latter has leaves with a glabrous adaxial surface.

Anderson (1923) has noted that the type differs slightly from most other material referred to *B. birchii*. The type specimen was collected from the northern margin of the range of the species. It is thus not surprising that it displays characteristics of many young and physiologically weak plants observed by one author (B.A.A.) in the field and in specimens grown from seed in the garden in Sydney. These plants generally differ from most *B. birchii* in having more linear shaped leaves, reduced development of fruits, longer internodes, and narrower stems. An examination of the type showed that it has been squashed flat and many of the fruits are now compressed. Evidence of the immaturity of the plant is found in the juvenile flower remnants at lower nodes. Most flowers have failed to develop seeds, fruiting perianths are small and leaves are smaller and more linear than those of a mature, healthy plant.

Variation within the Species

Some apparent morphological differences between specimens can be attributed to insect attack. Symptoms similar to the well-known " witches broom " condition in lucerne, *Medicago sativa* L., attributed to the eriophyid mite *Aceria medicaginis* Keifer appear on some *B. birchii* plants over most of its range. They appear to be the result of attack by another eriophyid bud mite, *Aculops bassiae* Keifer. On affected plants internode lengths are short, leaves are small and linear and flowers remain immature or are absent.

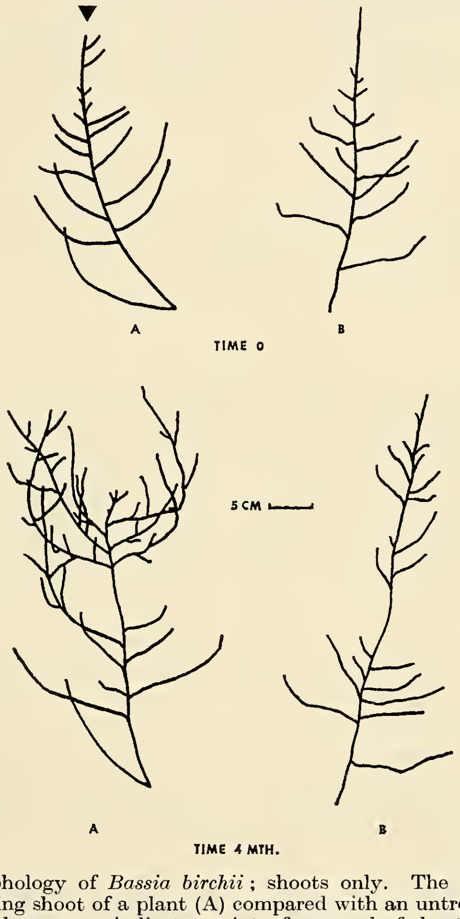

Fig. 1. Gross morphology of *Bassia birchii* ; shoots only. The effect of removal of the apical one cm of the leading shoot of a plant (A) compared with an untreated plant (B) after four months growth in a glasshouse. ▼ indicates point of removal of shoot tip. Scale is for length of shoots only.

Shoot tips are also often attacked by an undescribed tunnelling lepidopterous larva (*Mixodetis* sp. (Cosmopterigidae)). The tips become structurally weakened and eventually fall off. The effect of artificial pruning is quite dramatic ; the removal of apical dominance stimulates branching and the resulting plant has quite a different shape from that of an untreated plant. (Figure 1 compares the effect of removal of the apical one cm of shoot from the leading shoot of one plant with an untreated matched plant after four months growth in a glasshouse.) It is assumed that the effect of the larvae is similar to this artificial pruning and that differential attack by the insect may partly account for differences in shape of mature bushes. Larvae were not found on plants at the southern extreme of the range of *B. birchii* on the Riverine plain, and this may be the reason for a difference in shape between mature plants in that region and those from northern areas.

A spineless form of *B. birchii* was collected near Ivanhoe by Watson in 1970 (NSW 120365). It differs from normal *B. birchii* only in a reduced development of the perianth. In the field the spineless form is restricted to an area of approximately four hectares and occurs with normal spined plants. Seed from the spineless plants produced fertile spineless plants.

Apart from these variations in morphology, there did not appear to be any consistent differences in *B. birchii* over its range of occurrence in the field. Plants were raised in a glasshouse from seed collected over a wide area of the species' range and no consistent differences between plants from different sites were observed.

New Description of Bassia birchii (F. Muell.) F. Muell.

A densely branched robust perennial undershrub, up to one m high, stems clothed in a white tomentum. Leaves alternate obovate to oblanceolate, shortly petiolate, woolly on both surfaces ; generally, 4–7 mm wide and 12–18 mm long. Flowers solitary, axillary, sessile, hermaphrodite. Perianth hypogynous, turbinate and shortly convex on its woolly summit, the narrow opening (mouth) of the throat bordered by four irregular lobes, densely tomentose, hard when in fruit, obliquely attached at the base, with five acicular spines (± reflexed barbs), alternate with perianth lobes, two proximal at the summit of similar length (1–3 mm), adjacent to and generally obliquely parallel to the stem and three longer radiating divergently from an equatorial position obliquely perpendicular to the stem, either all three approximately the same length (8–15 mm) or one reduced (2–3 mm long). Stamens four, filaments flattened translucent, anthers versatile yellow. Style short, persistent, branching into usually three setaceous white stigmatic branches. Ovary superior monocarpellary and unilocular, ovule campylotropus. Fruit enclosed in the perianth, compressed, ovoid, brown, vertical to obliquely vertical. Embryo annular, green ; radicle and cotyledons erect, perisperm white, containing starch ; pericarp and testa membraneous.

Differs from *B. cornishiana* in orientation of spines, position of seed, shape of perianth, and usually in number of spines. *B. cornishiana* usually has six spines but may have five.

Differs from *B. convexula* in leaf shape and size and orientation of spines.

Differs from *B. quinquecuspis* in leaf shape, except for some specimens of var. *semiglabra* which can be readily distinguished from *B. birchii* by their lack of hairs on the adaxial surface of the leaf and by their generally less woolly tomentum and thinner branches.

Generally, only young or weak *B. birchii* have leaves of more linear shape than usual and only these could be confused with *B. convexula* or *B. quinquecuspis*. Care must be exercised in assessing perianth shape and spine orientation from herbarium specimens, as these may become distorted in pressing.

Cytology

Introduction

Wulff (1937) found variation in the somatic number of chromosomes in root tips of several Chenopodiaceae, including three *Bassia* species. He found the normal diploid number of chromosomes in the dermatogen and plerome regions but tetraploid as well as diploid cells in the periblem region. He noted similar variation in the Australian *Atriplex* species, *A. semibaccata* R. Br. and *A. spongiosa* F. Muell. Polysomaty was first recorded in the Chenopodiaceae by

Stomps (1910). It is defined as that condition wherein one or more tissues of diploid organism contain some cells of varying degrees of polyploidy. The polyploid condition arises by double reproduction of the chromosomes and at least one mitotic division always intervenes between two successive double reproductions (Witte, 1947). Witte suggested that the length of the meristematic region may be a factor in determining the degree of polyploidy in root tips of *Atriplex.*

Methods

B. birchii material from within the largest continuous area of infestation in New South Wales at Miandetta and from a southern infestation at Hay (Fig. 3) as well as the spineless form from Ivanhoe was examined. Seedlings were raised in petri dishes at 20°C in darkness (following germination in light).

Two days after germination the amount of free water in the petri dishes was gradually decreased. Root tips were removed after four days from germination and placed in 0·05% colchicine for 90 minutes at 25°C. The material was fixed in Bradley's fixative (4 chloroform : 1 glacial acetic acid : 3 alcohol ; by volume) for 60 minutes. Root tips were then macerated in 1M HC1 at 60°C for 60 seconds. Aceto-orcein was used to stain the material on a microscope slide for 15 minutes. Tips were then gently warmed for a few seconds with a spirit burner, squashed with a coverslip and tapped. The squashes were examined by phase contrast microscopy.

Results

The chromosome number in all the material examined was 2n = 18, which is the same as that recorded for three European *Bassia* species by Wulff (1937). The same diploid number is common throughout the family (Darlington and Wylie, 1955) and, indeed, the base number nine runs through all the European genera (Heslop-Harrison, 1953).

There was no evidence of polysomaty in *B. birchii* with or without colchicine pre-treatment. Divisions were only observed in the plerome region (in unsquashed root tips) ; the meristematic region was of very short length.

Distribution

Introduction

Herbarium records indicate that the species is generally restricted to central western areas of New South Wales and Queensland between latitudes 21°S and 36°S and the 300 and 700 mm average annual rainfall isohyets (Fig. 2). However there are records of the species from Jamestown (1944), Yongala (1964) and Balaklava (1972) in South Australia. There are also specimens from six localities in the Northern Territory which were collected between 1955 and 1973 (Fig. 2).

The occurrence of the plant in New South Wales has been the cause of particular concern to the grazing industry and it has been proclaimed noxious in most shires in the State for over 30 years. Although the species has been the subject of a number of unpublished preliminary investigations, the areas of serious infestation have not been clearly defined. The species was also the subject of unpublished mail questionnaire surveys to State and local government officers by Dodd (1934) and by the New South Wales Department of Agriculture and the Council of Scientific and Industrial Research in 1948. Beadle (1943) also mapped the distribution of several plant species, including *B. birchii,* in western New South Wales using counties as mapping units.

The object of the present survey was to define the limits of serious infestations within New South Wales as an aid to further study of the species.

Methods

There are a number of survey techniques for the estimation of abundance of plant species. Brown (1954) reviewed several methods, but these techniques are not directly applicable to surveying one or a few species over an extensive area.

Cover, expressed as the percentage of ground occupied by the perpendicular projection of the aerial parts of the subject species, is probably the most useful measure in the present case. It is particularly suited to large scale pasture weed surveys where the subject species forms a clumped or contagious distribution. Cover is independent of sampling unit size and comparatively easily assessed visually. It directly relates to the effect of many weeds (including *B. birchii*) whose main undesirable property is their occupation of useful space, and cover can usually be regarded as an integrating measure of competitive ability.

Fig. 2. Range of *Bassia birchii*. Unbroken line indicates main range of the species ; broken line indicates areas of isolated collections.

The assessment of cover may be simplified by using discrete classes and in the case of a plant which restricts stock movement, such as *B. birchii*, the area rendered inaccessible by the presence of plants, as well as the area actually covered, can validly be included in the area recorded as " covered ". *B. birchii* occurs on land of widely differing agricultural potential, and since small areas of dense stands are characteristic of the species and occur over its entire range, more than one minimum limit of the size of serious infestations was required. Cover was divided into two classes : (i) equal to or greater than 3% (serious infestations) and (ii) less than 3% (the other areas within its range). East of the 500 mm average annual rainfall isohyet (Fig. 3) the minimum size of a serious infestation was set at 40 hectares ; west of the 500 mm isohyet the minimum size of a serious infestation was set at 80 hectares. Because of fluctuating numbers in this species it would be impractical to show each individual infestation at any particular time. A map was prepared to show, as far as could practically be determined, the limits of serious infestations over the period 1970–73.

Results

Serious infestations are concentrated in the northern semi-arid rangeland region where neither crops nor pastures are usually sown (Fig. 3). There are small areas of serious infestation on agricultural land to the north-east of Coonamble and near Gilgandra, Narrabri and Boggabilla. Serious infestations to the south near Hay were not recorded in previous unpublished surveys.

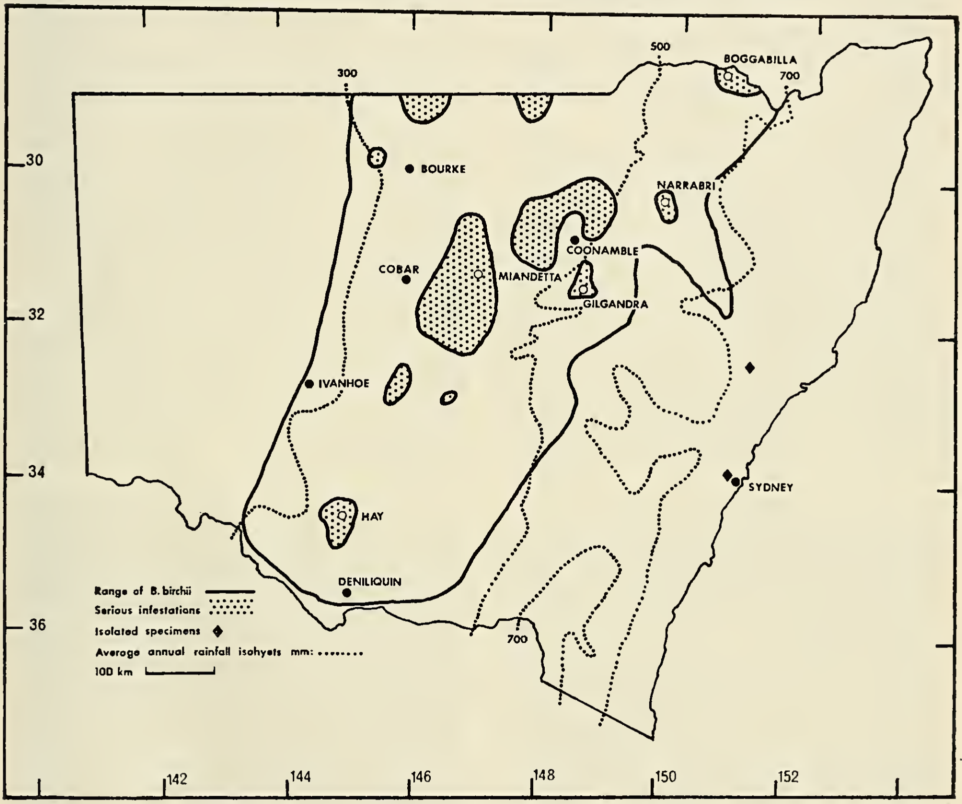

Fig. 3. *Bassia birchii* in New South Wales.

Throughout its range the species is restricted to soils of light surface texture. In northern areas it occurs chiefly on soils with gradational texture profiles: gravelly and non-gravelly neutral red earths (Gn 2.12) (Northcote, 1960) and sandy alkaline red earths (Gn 2.13), as well as on duplex texture profile soils: red brown earths (Dr 2.33) and solodised solonetz soils (Dy 5.43). In the Hay area to the south it generally occurs on the sands and loamy sands associated with prior stream courses.

Discussion

This species was first collected south of latitude 34°S in New South Wales in 1948 at Urana (35°18′S, 146°18′E). Although it was recorded as a rare plant or in small quantities in the questionnaire surveys there is no corresponding herbarium record and Beadle (1943) did not record it south of 34°S. Moreover, the species has apparently only assumed serious problem proportions in this region since the end of the drought of the mid 1960's. It appears that a gradual build up of "infection potential" took place in the period 1948–1968, which allowed the recent success of the species.

Seasonality of rainfall has probably restricted the colonisation of southern areas. Winter dominance of rainfall increases to the south in New South Wales and there is a high probability of very low rainfall in western areas during late spring, summer and early autumn (White, 1955). *Bassia birchii* has a requirement for extended period of high soil moisture conditions to establish a tap root and survive periods of moisture stress on gradational and duplex texture profile soils (Auld and Martin, unpublished data).

The requirement for an extended period of high soil moisture for establishment would also restrict westerly spread and northerly spread in Queensland into the more markedly summer dominant rainfall areas.

The faster growth rate of temperate plant species adapted to the moister environment to the east undoubtedly restricts the ability of this species to compete successfully and spread in that direction. However the range of the species extends to the foot of the tablelands areas and it is likely that low winter temperatures are the ultimate barrier to further easterly spread. Cambage (1914) has discussed the effect of the Great Dividing Range on vegetation. He stated that the Range produced three distinct climates in eastern Australia: "humid" to the east of the range, "dry" to the west, and "cold" on the range, and that the cold area acts as a barrier to intermingling of the humid and dry floras. He also noted certain gaps in the barrier effect, where western vegetation intruded into humid areas because there was no "cold" barrier. The upper Hunter region is the only such gap in northern New South Wales, and this is an area in which *B. birchii* has been collected a number of times since 1921. It has also been collected at the former Flemington stock sale yards in Sydney since 1968 where it has presumably been brought as fruits on stock from infested areas. Experimental evidence for the influence of low temperatures on distribution has been presented by Auld (1974).

The inability of the species to colonise soils of heavy surface texture may be related to an inability of *B. birchii* radicles to penetrate soils of high mechanical strength; especially as soil strength increases with decreasing moisture content. Taylor and Burnett (1964) have demonstrated the important influence of soil strength on root development and Campbell (1972) has found large differences between species in regard to the ability of their radicles to penetrate soils of various strengths. The physiological and anatomical bases for such differences have not been investigated. *Bassia* species could be useful experimental material to investigate this phenomenon, as certain other species, including *B. quinquecuspis* var. *quinquecuspis* and *B. bicornis*, are generally restricted to soils of heavy surface texture.

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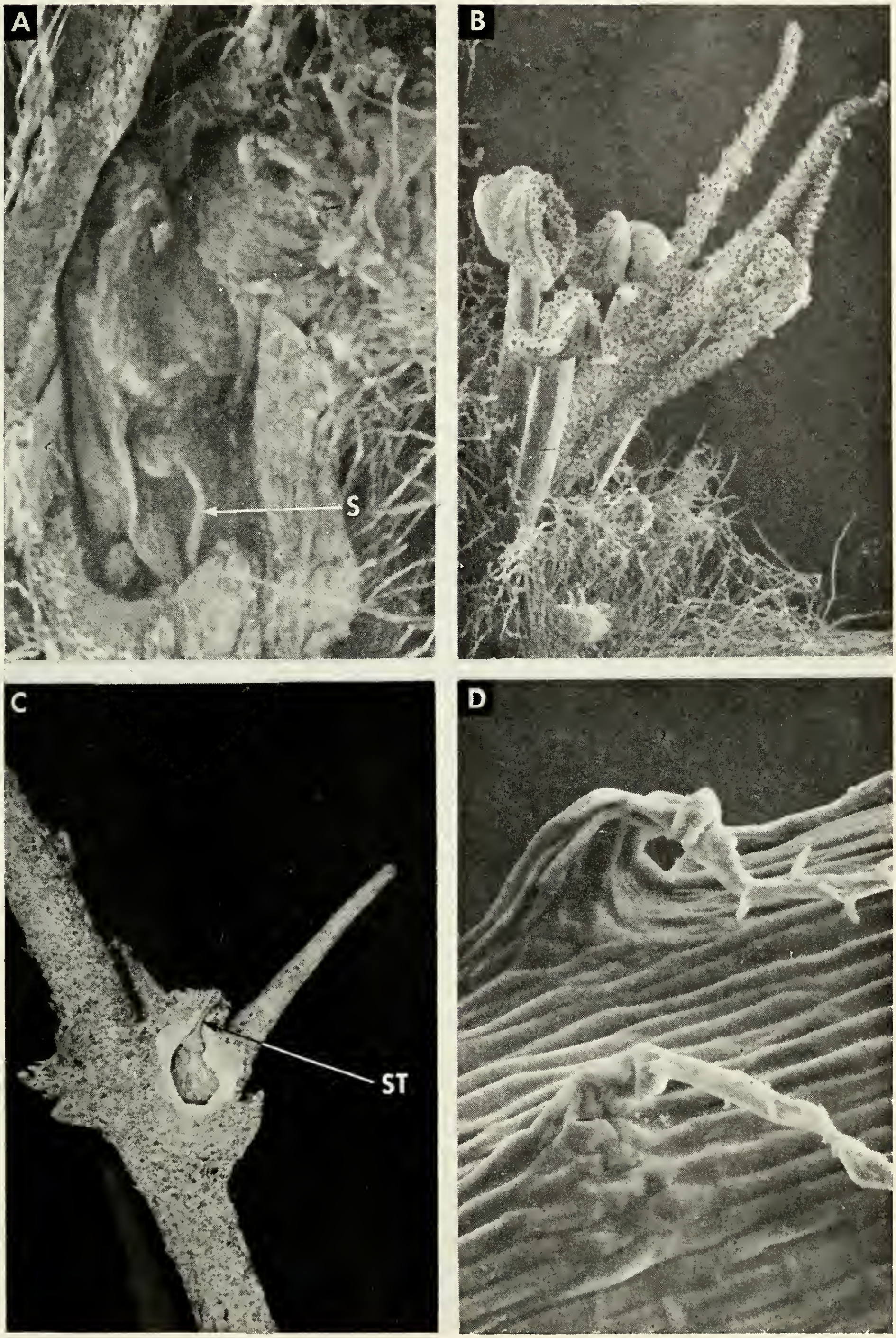
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